THE TIMBER LINE.

BY

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The upper limit of tree growth upon mountains differs greatly in altitude in different parts of the United States, in accordance with the range in latitude, in the elevation of the general surface of the country, in the exposure, and in the soil and rock conditions. The extremes are found on Mount Washington, N. H., where trees cease to grow at an altitude little exceeding 4,000 feet, and in southern Colorado, where they extend upward to over 12,000 feet.

The timber line is not a well-defined line across the mountain slope. For several hundred feet in altitude, the trees gradually diminish in height and symmetry, become more and more straggling and scattering, and finally end in detached clumps of nearly prostrate trunks, blown over into these attitudes by the wind. The line does not follow a contour around the mountain, but runs higher on southern slopes and in sheltered gulches and cañons, and lower on exposed northern slopes. On rocky mountains, timber does not climb as high as on those thickly covered with soil. On these accounts, measurements of the height of timber line are subject to some uncertainty, even when made with the greatest care, and it is never worth while to state them more closely than the nearest hundred feet.

The height above sea-level of the timber line on most of the mountain ranges of this country which rise above it has been measured. On Mount Washington, in the White Mountains of New Hampshire, its altitude is given as 4,150 feet. On Mount Marcy, in the Adirondacks of New York, it is 4,900 feet, showing a difference of several hundred feet, although these two groups of mountains are in nearly the same latitude. These two mountain groups, with Mount Katahdin in Maine, are the only ones east of the Rocky Mountains which rise above the level of tree-growth. The summits of the Southern Appalachians, although higher than the White Mountains, are far below timber line, owing to their more southerly latitude.

The Cordilleran ranges for the most part stand upon a high, broad plateau, extending from the northern to the southern boundary of the country, and extending over many degrees of longitude.

This plateau ranges in elevation from 4,000 feet to 10,000 feet above the sea, being highest in Colorado, and in that State the timber line is higher than anywhere else in the country. Many measurements of it have been made, showing an altitude ranging from 11,000 to 12,000 feet, with an average altitude of 11,500 feet. The differences are traceable to differences of latitude, or to difference in the height of the base of the mountain. Thus, Mounts Lillie, Park View and Arapahoe, Longs and James Peaks, on which timber line is given as 11,100, are in the northern part of the State. On Buffalo Peak it is 12,000; Mount Elbert, 11,900; Mount Harvard, 12,100; Mount Guyot, 11,800; La Plata Mountain, 12,000; Mount Lincoln, 12,000; Massive Mount, 11,600; Mount Princeton and Silverheels, 11,500. All these summits are in the central part of the State and rise from its highest plateau and valleys, in the midst of a perfect sea of high mountains. Pikes Peak, 11,700, a little further south, is the centre of a great mountain mass. In the southern part of the State are Rito Alto, with its timber line at 11,800; and Crestone, 12,100. Here the plateau is not as high as farther north.

In New Mexico, the altitude of timber line is no greater than in Colorado, since the effect of the more southerly latitude is offset by the diminished altitude of the plateau. In this Territory, outside of the Sangre de Cristo range, there are scarcely any mountains which reach the limit of timber; and in Arizona, but one peak, so far as known, San Francisco Mountain, rears its head into altitudes too great for tree-growth. On this ancient volcano, standing on a platform 7,000 feet above the sea, trees grow up to a height of 11,500 feet.

Going north and west from Colorado, we find, in the Uinta range, the timber line at an altitude of 11,100 feet, about the same as at the same latitude in Colorado. All other mountains of Utah are, or might be, were it not for aridity, or want of soil covering, timbered to their summits.

In the Wind River range of Wyoming, timber grows to an altitude of 10,200 feet; on Mount Washburne, Yellowstone National Park, to 9,900 feet; and on Sailor Mountain, east of the Park, it is 9,700. Still farther north, in Montana, it drops, on Mount Blackmore, south of Bozeman, to 9,500 feet; on Ward Peak, near the Three Forks of the Missouri, to 9,200; and on Mount Delano, near the north end of the Absaroka range, to 8,800. Going still farther north in Montana, the upper limit of timber growth seems to hold its altitude, for in the Flathead Forest Reserve, which extends from the

Great Northern Railroad to the northern boundary, and which includes the Front Ranges, the timber line maintains an average height of 9,000 feet.

The ranges to the westward in Montana and Idaho nowhere reach timber line, although the summits of many of them must approach it very nearly. It is not until we reach the Cascade range in Washington, that we find a true timber line again, and here it is much lower than in the same latitude in Montana. In northern Washington, it runs about 5,500 feet above the sea, rising to 6,500 on Rainier and the Cascades in its neighborhood. On Mount Hood, in northern Oregon, it is a little higher, say 7,000 feet, and it rises southward, reaching 8,200 feet at Crater Lake. On Mount Shasta, in northern California, it is 9,000; and on the Sierra Nevada, in central California, at Mono Pass, 10,750; while in southern California, in the San Bernardino range, Grizzly Peak, 11,700 feet, just reaches the limit of timber growth.

This sketch of the distribution of the timber line in the Cordilleras shows plainly the influence of the great elevated plateau on which the mountains stand, in increasing its altitude. Thus in Colorado, it is more than 1,500 feet higher than in the same latitude in California; in northwestern Wyoming, 2,000 feet higher than in Oregon; while in Montana, it is at least 3,000 feet higher than in Washington.

It is well known that this great plateau, although thousands of feet above the sea, has practically the same temperature as lowlands in the same latitude, owing to its great extent, and, since, as will be shown later, the height of timber line is essentially a question of temperature, this elevation of the timber line over these high plateaux is to be expected.

In the Cascade range, Sierra Nevada and San Bernardino range, is found a gradual and fairly regular rise of the timber line, from north to south, from 5,500 feet in northern Washington to 11,700 feet in southern California, a distance of 14° of latitude. As all conditions, except those incident to the differences of latitude, are much the same in these cases, we may examine this distribution as a question of latitude.

The following are the data in detail:

	APPROXIMATE LATITUDE.	TIMBER LINE.
Cascade Pass.....	48.30°	5,500
Mount Rainier.	46.51°	6,500
Mount Hood.....	45.20°	7,000

	APPROXIMATE LATITUDE.	TIMBER LINE.
Crater Lake	42.55°	8,200
Mount Shasta	41.25°	9,000
Mono Pass	38.00°	10,750
Grizzly Peak	34.15°	11,700

This table shows, in spite of some irregularities, an average change per degree of latitude of nearly 500 feet. If this rate continued northward, it would bring the timber line down to sea level in latitude 60°. We know, however, that in Alaska forests extend northward across the Arctic circle, and that in latitude 60° the timber line is about 3,000 feet above the sea, showing that the rate of descent of the timber line is not a simple function of the latitude, but that it diminishes as the latitude increases.

The ultimate and primary cause of the cessation of forest growth at great altitudes on mountain sides is to be sought for in temperature. This upper limit of tree growth is doubtless affected somewhat by the depth of the soil, by the steepness of slopes, by exposure to sun and to wind, and, in a few cases, by aridity, but these are all contributory agencies, and temperature remains the primary cause.

Within the United States, the mean annual temperature changes with each degree of latitude about 1°.7. At Duluth, Minnesota, in latitude 46° 47, it is 39°. At New Orleans, Louisiana, in latitude 30°, it is 67°.5. Also, the mean annual temperature changes 1° in every 300 feet, more or less, of abrupt ascent or descent. The observations of the Weather Bureau at Pikes Peak and Colorado Springs give for this factor 285 feet, and those at Mount Washington and Bethlehem, New Hampshire, give 290 feet. A change of a degree of latitude corresponds, therefore, to a change of elevation of about 500 feet, which is the amount which the timber line changes for each degree of latitude, as was above shown. This is not a coincidence, but a verification of the close relationship between timber line, temperature and latitude. For example, at Crater Lake, in latitude 43°, the timber line is 8,200 feet. A point at the same elevation in the latitude of Mono Pass, 38°, should have a mean annual temperature 8°.5 higher. If the timber line at Mono Pass has the same mean annual temperature as at Crater Lake, it would be 8°.5 x 300 feet higher, *i. e.*, 10,750 feet, which is precisely the observed altitude.

This leads naturally to a discovery of the mean annual temperature of the timber line. Knowing the height of timber line on a mountain and the altitude and mean annual temperature of a station

at its base, we have, with the rate of decrease of temperature with altitude, *i. e.*, 300 feet per degree, Fahrenheit, all the data necessary. I have computed it in forty-one cases, scattered widely over the country, with the following results:

DEGREES OF TEMPERATURE.	NO. OF CASES.
27	5
28	5
29	8
30	10
31	9
32	4

The mean of these figures is 29°.6. It may, therefore, be accepted that the mean annual temperature of timber line is 2 or 3 degrees below the freezing point.

The discordance among the results, which range over 6° of temperature, is probably due to the minor causes of variation in the elevation, such as slope, exposure, soil, etc. It is not due to differences of latitude, or of the altitude of the mountain's base, nor to difference in the species of trees, since the results show no order or system whatever in their discordance which suggest these causes. Mount Marcy in the Adirondacks, standing on a platform of slight elevation, with birch as the timber line tree, yields the same result as Mount Guyot, in central Colorado, much farther south, on a platform of 10,000 feet, and with *Pinus flexilis* as the timber line tree; so does Mount Rainier, Washington, whose base is little above sea level and whose timber line tree is the Alpine fir. In Colorado, where the major conditions are much the same, the results show quite as great a range as in the country at large.

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